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ORIGINAL PAPER

Population status and regeneration of a tropical clumping bamboo *Schizostachyum dullooa* under two management regimes

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Abstract: *Schizostachyum dullooa* (Gamble) Majumder '*dolu bamboo*' is a thin walled sympodial moderate sized to large tufted bamboo, dominant in the successional fallows of northeast India. The impact of resource management on productivity and sustainability of the species was evaluated by investigating the population status and regeneration in Cachar tropical semi evergreen forest under private property resource management (PPRM) and common property resource management (CPRM) regimes. Population status revealed current-year, one-year, two-year and three-year-old culms contribute 54%, 24%, 16% and 6% of the total culms per clump, respectively, under PPRM. Three-year-old culms were absent in CPRM and population status was thus represented by current year (83%), one-year (16%) and two-year (1%) old culms. Net change, rate of change and % gain in population for different age classes showed the prevalence of management practices under CPRM was unscientific. Efficiency of new culm production per clump used as an index of regeneration was 69.7% in PPRM and 59.88% in CPRM. New culms produced under CPRM were small and thin. We conclude that CPRM is inappropriate for a long term economic and ecological sustainability of the species and alternative management protocols are needed for conservation of the species.

Keywords: management regime; population structure; production efficiency; *Schizostachyum dullooa*.

Introduction

Schizostachyum spp. Nees is listed as one of the 38 high priority bamboo species identified for international action by INBAR and IBPGR (Rao et al. 1998). *S. dullooa* is also considered among the 19 priority bamboo species of India identified by the National Mission on Bamboo Applications (NMBA) (Haridasan and Tewari 2008). This is a dominant bamboo species in the successional fallows of northeast India regenerating after slash and burn agriculture (Rao et al. 1990). The species has limited distribution in forest tracts of northeast India to Bangladesh, Nepal, Bhutan, and Myanmar (Banik 2000) and is one of the most commercially important sympodial forest bamboo species growing naturally in the hilly tracts of Barak Valley (Nath et al. 2007). The importance of the species as the provider of ecosystem services is clear from the numerous ways through which it generates services. Internodes of the green culm are used for preparation of a traditional food during the religious harvest festival in addition to its wide range of uses in house construction, fencing and craft making (Nath et al. 2007). Young shoots of the species are also a food item of Phayre's Leaf monkey (*Trachypithecus phayrei*) during rainy season. Although the species is plentiful in northeast India, areas of shortage and overexploitation still exist because of uneven distribution, inaccessibility, population pressures and localized industrial demand. The indiscriminate extraction from natural populations coupled with large-scale habitat loss has seriously endangered bamboo genetic resources (Nath et al. 2007). Ever since the publication of Hardin's articles 'The Tragedy of the Commons' (Hardin 1968), there has been a growing debate on common pool resources, property rights, and resource degradation. The concept has been used to explain overexploitation of resources and other problem of resource misallocation (Stevenson 1991). Increasing commercial utility of the species from the hilly tract of Barak Valley has reduced its productivity (Nath et al. 2007). In view of greater exploitation of the species, the present study aims at acquiring information on population status and regeneration of *dolu* bamboo subject to private property resource management (PPRM) and common property resource management (CPRM). Knowledge of such study may help us to define management approach to increase the production efficiency of bamboo clump (Nath et al. 2006) as proper management systems for natural bamboo forest are required to

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ensure sustainability of supplies.

Materials and methods

Study area

Cachar is the largest district of Barak Valley of Assam with 58.76% of forest cover (FSI 2005). Forest vegetation of Cachar comes under Cachar tropical evergreen and semi evergreen forest (Champion and Seth 2005). Bamboos in the forest are primarily seral type and its occurrence is attributed to heavy biotic interference in the evergreen forests. The climate of the study site is subtropical warm and humid with average rainfall of 2 226 mm, most of which is received during the Southwest monsoon season (May to September). Southwest monsoon usually operates for a longer spell in the Northeastern region compared to the other parts of India. Average maximum and minimum temperatures were 30.5°C and 20.3°C, respectively.

Present study was carried out in selected stand of Cachar tropical semi evergreen forest of Cachar district Assam under private property resource management (PPRM) and common property resource management (CPRM) regime. The study area is situated between 92°45′24.6″ E and 24°40′53.2″ N. Map of the study site is depicted in Fig. 1. The selected site for PPRM is a 10-ha mixed condition of *dolu* bamboo growing under story of other woody tree species. The stand is managed by a farmer for household and commercial purposes. Stand density of the site was 215 clumps·ha^{-1}. Spacing between the clumps was 4–6 m. Management system includes selective felling with higher intensity during winter. The site for CPRM is a 49-ha natural forest patch surrounded by three villages. A total of 65 villagers visit the forest stand daily, of which 34% are male, 29% are female, and 37% are children. Male members mainly collect the green culms for household purpose and for selling in the market (Nath et al. 2007). Unlimited harvest of culms took place through out the year. *Dolu* bamboo is the most dominant plant species in the forest understory of the large tree species of *Artocarpus chama* Buch-Hum. and *Tetrameles nudiflora* R.Br. According to local villagers approximately 40–50 years ago, larger woody trees dominated the forest stand. Subsequent felling due to population upsurge and construction activities rapidly dwindled the forest trees, shifting resource use of local villagers from timber products to the non-timber forest products (Nath et al. 2007).

Data collection

Information on the utilization pattern of the *dolu* bamboo was gathered through structured questionnaire survey and field observation. For population status and regeneration study, 40 clumps from PPRM site and 50 clumps from CPRM site were selected through stratified random sampling and marked with paint. The marked clumps were monitored regularly from November 2007 to November 2008. Bamboo culms were categorized into different ages depending on their maturity: (1) current year, (2) one year old, (3) two year old, and (4) three year old (Banik 2000; Nath et al. 2004).

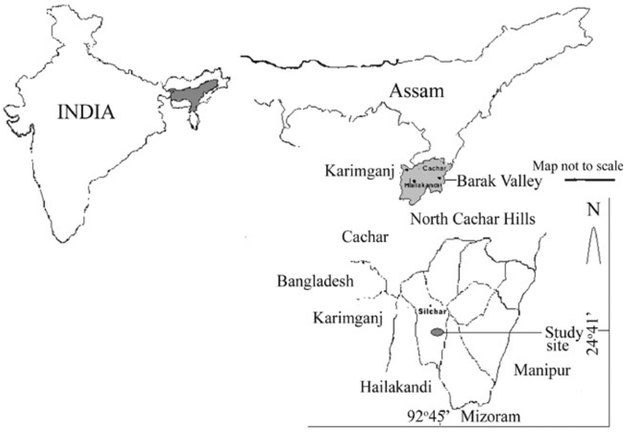

Fig. 1 Map of the study site.

Statistical analysis

Population status of the studied stand from Nov. 2007 (A) to Nov. 2008 (B) was evaluated from the calculated values of net change (B-A), rate of change (B/A), and percentage gain [(Net change × 100)/A].

Regeneration of the studied stand was evaluated through calculating production efficiency (PE) of the clumps as:

$$PE = N_n / \Delta T \times 100 \qquad (1)$$

where, N_n is the number of new culms produced in the *n*th year, and ΔT is the total of current and one year old culms per clump of the previous of *n*th year.

PE was calculated based on the assumption that younger culm ages (current and one year old culms) contribute more towards annual new culm production (Chaturvedi 1988; Lakshmana 1990; Kleinhenz and Midmore 2001).

Culm height (m) and culm DBH (cm) of new culms produced in 2008 were measured during November when culm growth stabilized.

Results and discussions

Utilization of *dolu* bamboo is diverse. Commercial purpose includes selling green/dead culm in market, local industry or to any household owner in the village. Internode of the green culm of the species was also used for the preparation of a traditional food item during the harvest festival. Household purpose includes construction of new and repairing of old houses. In CPRM, highest quantity (40%) of culm was utilized for household purposes against commercial purposes (68%) in PPRM (Fig. 2). Pattern of traditional housing and construction technology in the nearby villages of the study site are entirely dependent on bamboo resources. Bamboo in north east India has wide acceptance for construction of houses due to its desired structural properties of size, shape, flexibility and strength (Laha 2000).

Culm population structure under both the management regimes exhibited the upright pyramid with wider base and taper apex. Under the PPRM population structure was represented by four culm ages against three culm ages in CPRM. Current and one year old culms respectively account for 50%–57% and 23%–38% of total culms per clump in PPRM, and for 80%–85% and 15%–25% in CPRM (Fig. 3). Culm age structure in PPRM regime corresponds to the recommended age structure (Yuming et al. 2001) for optimum yield, yet characterized by higher proportion of current year culm. Therefore, the culm population structure of PPRM is a more stable structure for maintaining the stand productivity than that of CPRM. The high percentage of current year culms along with low percentage of older culm ages in CPRM imitates the lack of management system in CPRM. A few studies have related productivity of bamboo to the age structure of the stand (Lakshmana 1990).

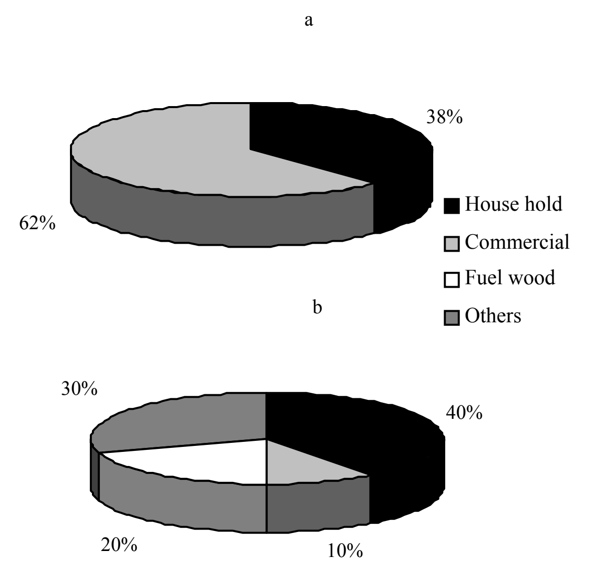

Fig. 2 Utilization of dolu bamboo in private property resource management (a) and common property resource management (b) regimes.

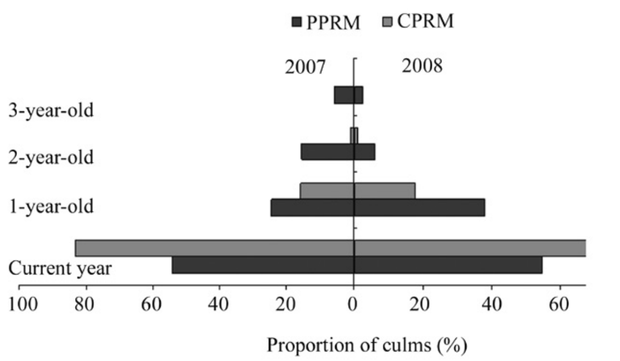

Fig. 3 Culm population structure in private property resource management (PPRM) and common property resource management (CPRM) for 2007 and 2008.

Total number of culms recognized a marginal increase of 2% in PPRM whereas in CPRM it recognized a decline of 27% of total culms. Culm dynamics in PPRM showed the increase in current year culm and total number of culms per clump. Net change and rate of change were greater under PPRM (Table 1). Reduced net change and rate of change of culm in CPRM corresponds to the higher intensity of felling without considering the standing stock, culm ages and felling period. Negative percentage gain was recognized for different culm ages in CPRM that reflects the greater pressure on sustainable productivity of the bamboo stand. Regeneration was higher in PPRM than CPRM (Table 1). New culms produced in CPRM were significantly smaller and thinner than PPRM ($p < 0.001$) (Fig. 4). Mean culm height was 9.28 m and 6.41 m for PPRM and CPRM, respectively. Mean culm DBH was 4.12 cm and 2.89 cm for PPRM and CPRM, respectively. Retention of less number of culms per clump in CPRM can not maintain the rhizome vigour for superior growth of culms over the year and therefore, substantially reduce the culm height and size. Reduced culm size may decline the basal area of the clump and thus substantial loss of photosynthetic potential. The size of new culm was determined by the nutrient supply from the rhizome (Ueda 1960). This suggests that the culm size and its height are the response of the rhizome vigour. For many sympodial bamboo species in India culms >2 years contribute only a little to growth of new culm (Chaturvedi 1988) and it appears that 1 to 2 year old culms must be left to reach productive stage (Kleinhenz and Midmore 2001). Harvesting should be conducted so as to cause a minimum of disturbance, and it is essential to retain a portion of old culms both for mechanical support of new shoot and to maintain the rhizomes in full vigour (Huberman 1959).

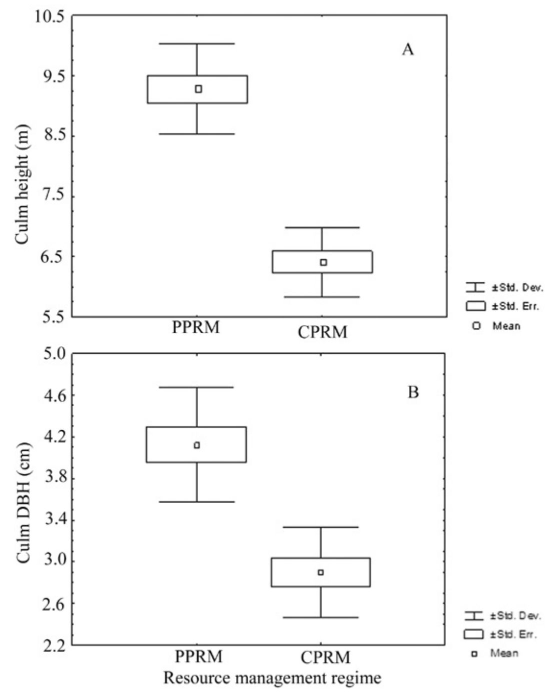

Fig. 4 Culm height (A) and culm DBH (B) of new culms produced in private property resource management (PPRM) and common property resource management (CPRM).

The consequences of overexploitation under CPRM have direct effect on population status, culm characteristic and regeneration potentiality. When property rights to natural resources are absent and unenforced the result is free riding and over exploitation (Hardin 1968). Higher intensity of exploitation in a low productivity area can further affect the ecological and economic sustainability of the species and can lead to the elimination of the species from a given area. Therefore, alternative management protocol (Franklin 2006; Nath et al. 2006) is desired to protect and manage the species for the restoration of the habitat as well for the conservation of the species.

Table 1. Population status of *S. dullooa* from Nov 2007 to Nov 2008

Management regime	Culm age (years)	A. Nov 2007 (No. of culms/clump)	B. Nov 2008 (No. of culms/clump)	C. Net change (B-A)	D. Rate of change (B/A)	E. Percentage gain (C ×100/A)	F. Production efficiency (%)
Private property resource management (PPRM)	Current	27.65±5.83	27.95±6.28	0.3	1.01	1.08	69.70
	One	12.45±3.61	19.4±3.96	6.95	1.56	55.82	
	Two	7.9±2.03	3.0±0.96	-4.9	0.38	-62.03	
	Three	2.85±1.02	1.25± 0.34	-1.6	0.44	-56.14	
	Total	50.85±8.26	51.60±9.2	0.75	1.01	1.47	
Common property resource management (CPRM)	Current	14.0±3.28	10.0±5	-4	0.71	-28.57	59.88
	One	2.7±1.12	2.15±3.12	-0.55	0.8	-20.37	
	Two	0.15±0.05	0.10±1.06	-0.15	0.67	-33.33	
	Total	16.85±4.31	12.25±0.02	-4.6	0.72	-27.3	

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